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ROSE BUSHES IN RELATION TO POTATO CULTURE

Patch

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BULLETIN 303

ROSE BUSHES IN RELATION TO POTATO CULTURE.[1]

By Edith M. Patch.

The attention of the writer was first drawn to the "pink and green aphid of potato"[2] in August, 1904, when it was reported numerous and troublesome on potato vines at Houlton, Maine. That this siege was of three years' duration is recorded in the statement in Insect Notes for 1906 (1)[3] to the effect that "*Macrosiphum solanifolii* has for three seasons attacked the potato vines to an injurious extent in the vicinity of Houlton and elsewhere. The colonies cluster thick on stem and leaf, thousands to a plant, frequently wilting the stems and drying the leaves..... The fall generations of this species do not appear upon the potato. It is not yet known what plant serves for the alternate host."

On account of the presence of this aphid for three consecutive seasons in numbers which assumed the character of a plague to many Maine potato fields, it seemed desirable for the writer to undertake a study of the species with especial reference to ascertaining the "alternate host" (*i. e.* the plant to which the winged migrants fly in late summer and upon which the overwintering eggs are deposited),—this being at that time the missing link in the life cycle of the insect.

The fall of 1906 and the spring of 1907 were devoted largely to that project and it was with considerable chagrin that the writer had to confess that the identity of the "alternate host" was still unascertained—the link was still missing. It was not, indeed, until seven years later that an aphid which had been annually collected from rose bushes was suspected of being the same as the pink and green aphid of potato. The fact that the writer had been collecting this species from rose ever since May,

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[1]Papers from the Maine Agricultural Experiment Station: Entomology No. 109.

[2]The Plantlouse known as *Macrosiphum solanifolii* Ashmead.

[3]Reference is made by numerals to "Literature cited," p. 344.

1904, and from potato since August, 1904, without realizing that it was the same seems incredible in retrospect. However, the "dual personality" of migratory aphids has thrown entomologists off the scent sometimes for a century at a stretch; and the writer was not the only aphid hunter in the country who was holding rose-bred specimens of *Macrosiphum solanifolii* under a manuscript name expecting later to describe it as a "new species."

In July and August, 1915, (2) all doubts of identity were definitely settled by transferring spring migrants from rose to caged potato plants and rearing, on potato, the descendants of the rose aphids through several generations. The missing link in the cycle was thus made evident. The rose bush was the long sought overwintering host of the pink and green aphid of potato.

The calendar for this aphid thus established, for a while there was no real reason for devoting research time to *Macrosiphum solanifolii;* and it was not until the fall of 1920 that circumstances seemed to justify placing work with potato aphids again on the schedule and this time, by vote of the Station Council,[4] as the main entomological project for 1921. In accordance with this action the writer went to Aroostook Farm, at Presque Isle, for the purpose of intensive study of potato aphids with particular reference to their probable field relation to the spread of certain potato diseases. For in 1921 the significance of aphids on potato was recognized to be of an importance entirely unsuspected in 1904. We now know that we have to fear not only the direct injury to the plant by a heavy infestation of aphids but also the indirect work of these insects in their role as carriers of certain potato diseases (8) (11) (12) (14) (15). It was therefore to supplement, from the standpoint of entomological observation, the potato disease work being carried on at Presque Isle, that this project was undertaken; and though no formal cooperation was entered upon it was mutually understood that the writer was immediately to turn over to the resident plant pathologists all entomological observations having any bearing on the investigations in progress.

On the other hand there should be acknowledged the help rendered by Dr. Donald Folsom and Dr. E. S. Schultz in keeping the writer in touch with such phases of the potato disease

[4]November 1920.

work as might seem to throw light on the insect side of the problem.

THE PINK AND GREEN APHID OF POTATO.

This species is the largest of the aphids feeding on potato. It is subject to pronounced color variation, being either green or pink; and to those marked differences in structure, common among aphids—some individuals being winged and others wingless. It is rather a restless species and the wingless forms are somewhat inclined to drop from the plant when disturbed. The abdomen is not marked with dark, but is ordinarily clear in color either pink or green, though sometimes individuals may be found with a mottling, part pink and part green; and sometimes rather yellowish specimens are found. The mature forms are often rather glistening, but in the younger stages at least, the insect usually has a median line of dark green or pink (according to the color of the individual) while the rest of the body is paler by virtue of a very slight powdery deposit. This appearance is more noticeable in bright light. See Figure 50.

LIFE CYCLE.

(See Diagram)

The pink and green aphid of potato feeds in the spring on the succulent new growth of rose bushes which are the primary or spring food-plant of this species.[5] The first forms to appear each year are wingless females which hatch from black glistening eggs that were laid on the rose the fall before and that have overwintered on them. The eggs hatch at a time when the spring growth of the rose is tender and juicy and the young aphids have suitable feeding conditions. Because these first wingless females are the progenitors of all the succeeding generations for the season, they are called the "stem mothers." The stem mothers are the only generation that hatch from eggs. When they become full grown,[6] they begin to bring forth living

[5]For further discussion of foodplants see pages 326, 327.

[6]At Presque Isle in 1921 the stem mothers were mature and producing young June 2; though on account of the early season, this seems probably an unusually early date for that locality.

LIFE CYCLE OF THE PINK AND GREEN APHID.

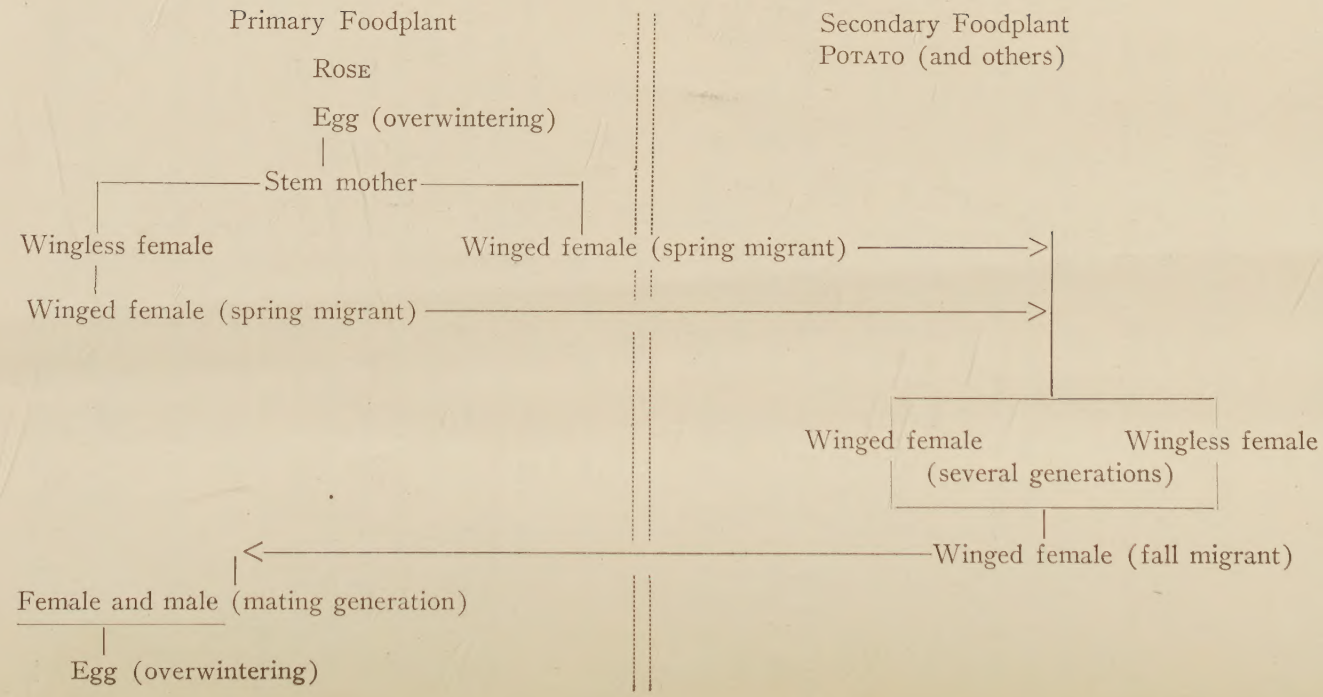
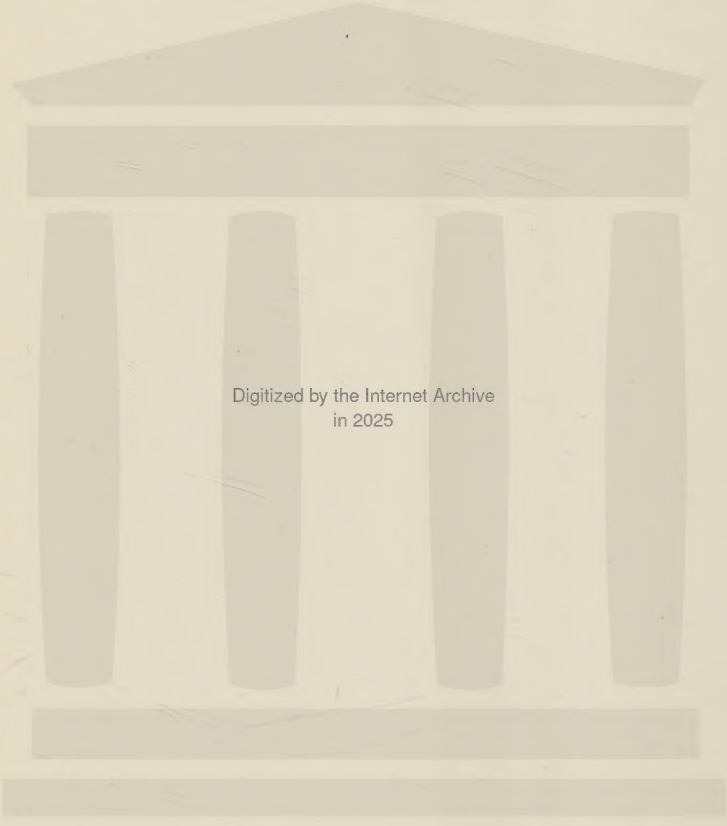


Fig. 50. The pink and green aphid on potato.



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young and continue to produce in this way for about two weeks.

The progeny of the stem mothers are either pink or green. Part of them develop wings and part are wingless forms. The winged individuals of the second rose generation are the earliest of the "spring migrants;" and after they become mature, they no longer feed upon the rose but take flight to some plant suitable for their summer colonies—such a plant being called the secondary or summer foodplant.[5] For this purpose there seems to be nothing in any part of the country they prefer to some member of the Nightshade Family. Now in the chief potato areas of Maine wild members of this family are not abundant. Of the cultivated members, we find occasionally a few rows of tobacco evidently grown for home consumption, what tomatoes are grown in home gardens, and vast expanses of potatoes. Nothing could suit the needs of this aphid better than to have the country stripped of its native vegetation and planted to a favorite food. The migrants after leaving the rose have not far to seek their summer fortunes in neighboring potato fields.

As has been indicated, only a part of the second rose generation become winged and desert the rose bush. The wingless forms remain and bring forth their broods of young on the spring food plant. These, the third rose generation, for the most part become winged when mature and constitute the later spring migrants, seeking the potato in the same way as the winged members of the second rose generation.

While living during the summer on the potato, the two color-varieties of females, either green or pink, bring forth their successive generations of young, both winged and wingless. The wingless ones do not stray far from the plant they grow up on although they move to different parts of the plant or to neighboring plants if the one they are on becomes overcrowded with their colonies. The winged summer forms disperse over the potato field; and, if they have been feeding on plants sick with mosaic or leafroll (and perhaps other diseases), take the contamination with them and inject it into the tissue of such healthy plants as they may chance to feed on.

During late summer and early fall, there develop on the potato winged individuals that differ from all the previous

winged forms of the season in that, after acquiring wings, they have no further interest in the summer food plant. These are the "fall migrants" or "return migrants" and their flight, as their name indicates, takes them to the rose—the primary food plant of the species and that upon which the overwintering eggs are to be deposited.

It is not, however, the return migrants that deposit the eggs; for they, like all the previous generations of the season beginning with the stem mother, produce live and active young. Part of these young develop into wingless females and part become winged males. As these females represent the last generation of the season and as they produce eggs instead of living young, it will be seen that they are an important link in the economy of the species for upon them depends the production of overwintering eggs. The males in this same last fall generation are the only males which appear during the season, all the other generations being comprised of females only.

The eggs, which remain over winter on the rose, are those from which hatch the "stem mothers" or the first rose generation of the spring.

This process is repeated from year to year by the pink or green aphid—the fall generations, the overwintering egg and the spring generations living on the "primary host"; and the summer generations multiplying to great numbers on a "secondary host." And this is, in the main essentials, the manner of other related migratory aphids.

PRIMARY FOODPLANTS.

The primary foodplant of an aphid is the species of plant on which it habitually deposits its overwintering eggs and on which develops the spring generation of stem-mothers. It is usually the case that a migratory aphid uses some tree or woody shrub for the primary host even when living on herbs during the summer. Most aphids are confined to a single genus of plants for primary host purposes, or at most a few closely related genera; and some are restricted to a single species of plant.

The writer has never found the first two spring generations of *Macrosiphum solanifolii* developing on any other plant than a rosebush; and thinks there is no risk in stating that the rose is

the only primary host plant[8] of any significance for Maine conditions. That the rose serves as a primary host also in two such widely separated places as Colorado and England is an indication that the rose bush is the plant particularly adapted to the spring needs of this aphid.

SECONDARY FOODPLANTS.

Although it is not always the case, it is not uncommon for a migratory species of aphid to accept a much broader group of plants for its summer home than for its winter and spring home. The pink and green aphid under consideration has a conspicuously wide range of such secondary foodplants. It is not likely that the list is yet complete but the following records are at least suggestive of the catholic taste of this insect in the matter of vegetable juices.

Grass Family.

Zea mays L. Maize. Corn (2)

Lily Family.

Asparagus officinalis L. Garden Asparagus (9)
Disporum sp. (10)
Tulipa sp. Tulip. Greenhouse Laboratory, Columbia University. 1917. (T. H. Morgan)

Iris Family.

Iris sp. Orono, Me.; July 6, 1905, Greenhouse Laboratory, Columbia University, 1917. (T. H. Morgan).
Gladiolus sp. Orono, Me. Sept. 5, 1908; Sept. 6, 1912.

Canna Family.

Canna indica L. (6)

Nettle Family.

Ulmus americana L. American Elm (5)

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[8]There are a few scattering reports of this aphid on apple trees (4) but there is no indication recorded that the apple has anywhere figured as the normal over-wintering host. In 1907 captive aphids deposited eggs upon potato and shepherd's purse during insectary studies (2) on this species by the writer; but such does not appear to be the normal behavior of this aphid when unconfined.

BUCKWHEAT FAMILY.

Fagopyrum esculentum Moench. Buckwheat. Houlton, Me. Aug. 31, 1907.
Polygonum hydropiper L. Common Smartweed. (9)
Polygonum persicaria L. Lady's Thumb. (6) Orono, Me. Aug., 1918.
Rumex crispus L. Yellow Dock (6)
Rumex obtusifolius L. Bitter Dock. Arentsville, Pa. (S. W. Frost) Oct., 1918

GOOSEFOOT FAMILY.

Atriplex sp. Orach. (10)
Beta vulgaris L. Garden Beet. (3)
Chenopodium album L. Lamb's Quarters. Orono, Me. Sept. 15, 1915; Aug. 31, 1916; Presque Isle, Me., July 25, 1921.

AMARANTH FAMILY.

Amarantus retroflexus L. Redroot pigweed. Greenhouse laboratory, Orono, Me. Sept. 15, 1915; Presque Isle, Me. July 25, 1921.
Amarantus spinosus L. Thorny Amaranth. (9)

POKEWEED FAMILY.

Phytolacca decandra L. Common Poke (6)

CROWFOOT FAMILY.

Clematis crispa L. (7)

MUSTARD FAMILY.

Barbarea vulgaris R. Br. Common Winter Cress. (9)
Brassica alba L. White Mustard, Orono, Me. Aug. 1, 1918.
Brassica nigra L. Black Mustard. (9)
Brassica oleracea L. Cabbage. (9); Spring Valley, N. Y. July 30, 1917. (S. W. Frost).
Brassica rapa L. Turnip. (2)
Capsella bursa-pastoris L. Shepherd's Purse. (2); Presque Isle, Me. July 25, 1921.
Lepidium virginicum L. Wild Peppergrass. (9)

ROSE FAMILY.

Agrimonia grypsepala Walls. Agrimony. Orono, Me. Aug., 1918.
Potentilla canadensis L. Cinquefoil. Orono, Me. Aug. 10, 1918.

PULSE FAMILY.

Desmodium sp. Tick Trefoil. (9)
Lespedeza procumbens Michx. Bush Clover. (9)
Phaseolus vulgaris L. Bean. (2)
Trifolium arvense L. Rabbit-foot Clover. (9)
Trifolium incarnatum L. Crimson Clover. (9)
Vicia sativa L. Spring Vetch. (9)
Pisum sativum L. Garden Pea. (2)

WOOD SORREL FAMILY.

Oxalis sp. Wood Sorrel. (10)

GERANIUM FAMILY.

Erodium sp. Storksbill. (10)

RUE FAMILY.

Citrus sp. (10)

STAFF TREE FAMILY.

Celastrus scandens L. Waxwork, Climbing Bitter-sweet. (7)

BUCKTHORN FAMILY.

Ceanothus sp. Red-root. (7)

VINE FAMILY.

Cissus arborea L. Pepper-vine. (7)
Vitis sp. Grape. Walnut Creek, Calif. Sept. 27, 1912. (W. M. Davidson).

MALLOW FAMILY.

Althaea rosea Cav. Hollyhock. . (6)
Gossypium herbaceum L. Cotton. (9)

ST. JOHN'S-WORT FAMILY.

Hypericum perforatum. Common St. John's-wort. Orono, Me. Aug. 1918.

EVENING PRIMROSE FAMILY.

Fuchsia sp. (10)

DOGBANE FAMILY.

Apocynum androsaemifolium L. Spreading Dogbane. Presque Isle, Me. July 30, 1921.

MILKWEED FAMILY.

Asclepias sp. Milkweed. (7)

CONVOLVULUS FAMILY.

Convolvulus arvensis L. Bindweed. (9) Orono, Me. Aug. 31, 1910.
Ipomoea batatas Lam. (6)
Ipomoea purpurea. (9)

MINT FAMILY.

Mentha sp. Mint. Orono, Me. Aug., 1918.
Scutellaria galericulata L. Skullcap. Orono, Me. July 27, 1918.

NIGHTSHADE FAMILY.

Capsicum annum L. Red Pepper. (6)
Datura stramonium L. Jimson Weed. (6)

Datura tatula L. Purple Thorn Apple. (9)
Lycium halimifolium Mill. Matrimony Vine. (9)
Lycopersicum esculentum Mill. Tomato. (9) Frequent Maine collections.
Nicotiana tabacum L. Tobacco. (9) Presque Isle, Me. July 21, 1921.
Physalis pubescens L. Husk Tomato. Meriden, Conn. Sept. 21, 1908. (W. E. Britton)
Physalis pruinosa L. (9)
Physalis subglabrata Mackenzie & Bush. Iowa, June 22, 1912.
Physalis virginiana Mill. (9)
Physalis viscosa L. (9)
Solanum carolinense L. Horse Nettle. (9)
Solanum jasminoides Paxt. Pepper Vine. (2)
Solanum melongena L. Egg Plant. (2)
Solanum tuberosum L. Potato. From Maine to California. Canada.

FIGWORT FAMILY.

Verbascum blattaria L. Moth Mullein. (6)

BIGNONIA FAMILY.

Catalpa speciosa. (6)

PLANTAIN FAMILY.

Plantago lanceolata L. Rib Grass. (9)

GOURD FAMILY.

Cucurbita maxima Duchesne. Squash. New Haven, Conn. July 22, 1909. (A. I. Bourne); July 8, 1914. (M. P. Zappe)

COMPOSITE FAMILY.

Achillea millefolium L. Yarrow. (5)
Ambrosia artemisiifolia L. Roman Wormwood. (10). Orono, Me. Aug. 6, 1918.
Antehmis cotula L. May-weed. Orono, Me. Aug. 10, 1918.
Aster cultivated. (2)
Cineraria sp. (2)
Deinandra sp. (10)
Helianthus annuus L. Common Sunflower. (6)
Lactuca sativa L. Lettuce. (2) (8) New Haven, Conn. July 22, 1909. (A. I. Bourne) Irondequoit, N. Y. Greenhouse, Jan. 5, 1917.
Rudbeckia hirta L. Black-eyed Susan. (9)
Senecio aureus L. Golden Ragwort. Orono, Me. July 3, 1918.
Sonchus oleraceous L. Common Sow Thistle. (2)

ECONOMIC IMPORTANCE.

Injury to plant by feeding. In years of great abundance, there is no doubt that the direct injury due to the work of these aphids is a serious matter for the potato plant. At such times

the colonies of these pests practically cover the tips of the growing shoots and crowd thick upon the terminal leaves—parts of the plant particularly tender and therefore susceptible to injury. Though the individuals are small, they mass their colonies in great numbers, frequently thousands to a plant; and as they keep their beaks plunged into the plant tissue and suck sap almost constantly, this drain upon the vital juices of the plant must, in itself, be a severe tax. This species does not confine its attack to the terminal shoots and leaves; but colonizes the blossom clusters which wilt and wither under severe attack. Colonies also occur on the underside of the lower leaves. This the writer found to be one of the favorite resorts of the pink and green aphid at Presque Isle during the season of 1921. Certain observations that were made lead to the conclusion that the choice of those broad leaves that touch the ground, on "over-grown" plants such as Aroostook conditions produce, may be due to any one of such various causes as an attempt to seek shelter from heavy wind or rain storm, or from the sun during a time of excessive heat. It seems probable that the ground leaves will be used more by this species during a very dry season than a wet one. It is the habit of an aphid, after experiencing its last molt and becoming ready to give birth to young, to seek a situation a little apart from the crowd in which she has been undergoing her own development and the weather conditions at such a time may well influence her movements and thus indirectly the location of her brood of young. Aphids shift their positions, too, at other times if disturbed; but the real dispersal over a given plant or to another takes place at the time an individual becomes mature and is about to produce young. The wingless females at this time have, of course, a much more limited dispersal range than the winged ones. Both wingless and winged females develop during the entire time spent upon the secondary host, though late in the season the latter greatly out-number the former. During the summer these females confine their attention to the potato or other secondary host. In late summer and fall the winged individuals of the "migrant generation" take flight to the primary host plant (the rose). The fate of the dwindling number of wingless females depends in general on weather and climate. In the north they die out. In the south they doubtless persist during the winter on some secondary food plant; as is the case with many other species of migratory aphids which in the north are

dependent upon the over-wintering eggs deposited upon the primary host, but which in the south may continue to link one season with the next by successive generations of viviparous females.

Injury to plant by carrying disease. More insidious than the direct damage by aphids in feeding is the harm rendered in transferring disease from sick plants to well ones. For aphids, feeding as they do by plunging their beaks into the juices of the plant, are able to innoculate one plant with virus they have taken from another.

On theoretical grounds this would seem logical; and it has been demonstrated experimentally that at least two potato diseases, mosaic (11) (12) and leafroll (8) (14) (15) are subject to transmission by aphids. Correlated with these indications is the conclusion, based upon the examination of more than one hundred fields during the summer of 1921, that in general the percentage of mosaic has been increasing conspicuously more in localities favorable to aphid infestation than in localities where conditions for aphids are unfavorable. The writer visited these fields personally in order to study the aphid situation in northern Maine and Northern New Brunswick and, through the advice of the plant pathologists who entered the same fields for mosaic counts, was enabled to form some estimation of the bearing of aphids on the mosaic percentage under natural field conditions.

ECONOMIC IMPORTANCE OF POTATO MOSAIC.

It may not be inappropriate at this point to state briefly the case of potato mosaic with reference to the seed potato industry. The southern states are dependent on northern grown potatoes for seed; and potatoes having mosaic, when grown in the south, are much more seriously affected than when grown in the north. For this reason northern grown potatoes tainted with mosaic, though suitable enough for table use, are not desired by southern planters. Mosaic is, therefore, an economic danger to the seed potato business; and a northern grower who can produce mosaic-free stock can command southern markets that are closed to his less successful rivals. As evidence of this fact it may be interesting to refer to a recent Louisiana bulletin (13);—

"The disease of Irish potatoes, known as the mosaic disease, or sometimes locally as the curly leaf, is the most important

potato disease in Louisiana. It occurs in every section of the State where the Bliss Triumph variety is grown and frequently causes a very heavy loss. A loss of fifty per cent or more is not at all uncommon and occasionally the crop in some fields is a total failure. During the season of 1921, a great many growers did little better than to get their seed back.....

"The loss from mosaic seems to be much greater in Louisiana than in the northern potato-growing districts. This is probably due to the higher temperature.....In the northern states, there are records of high yields even with a considerable mosaic infection, but this is not the case in the South. The plants seem to be weakened by the disease and the hot weather causes them to go to pieces.....

"The amount of mosaic in the seed seems to be one of the important deciding factors in the productiveness of the strains. All the low yielding strains, whether certified or uncertified, showed a high percentage of mosaic, while all of the high yielding strains showed a low percentage of mosaic.....

"All of the results show definitely that a greater consideration must be given the mosaic disease by the northern growers of certified seed if they expect to make this seed popular in the southern states."

A Word With Reference to Leafroll.

While leafroll is by no means unknown in Maine, it occurs, for the most part, outside of northern Aroostook.[9] It would complicate a report on the rather clear cut conditions of that part of the State to include a treatment of leafroll on the same terms that are given mosaic. It would not, however, be out of place to state that since the pink and green aphid is known to carry leafroll (14) (15) it might be advisable for growers in localities troubled with that disease, to keep the vicinity of their potato fields as free from rose bushes as is convenient, for this would at least reduce by one factor the spread of any disease that is carried by the pink and green aphid.

The Rose Bush Situation in Northern Aroostook.

The fact that the writer, in seventeen years collecting of Maine aphids, had not found the pink and green potato aphid on

[9]According to observations by Drs. Donald Folsom and E. S. Schultz.

any primary, or spring, food plant other than the rose, taken together with the circumstance that wild roses had been reported to be not abundant in northern Aroostook, made an entomological visit to the potato fields of this part of the State desirable for several reasons. Was this species of aphid accepting in that vicinity a primary host not recorded for other parts of the country? If not, were there actually enough roses in northern Maine to support the aphid infestations that occur there, on potatoes? For the purpose of investigating these and related matters, the writer spent three months with headquarters at Aroostook Farm, Presque Isle.

Beginning the middle of May an intermittent canvass of about twelve weeks' duration was made of the vegetation of hedgerows between fields, woodland fringes, swamp borders, and hillside growths, with special reference to locating wild rose bushes. This canvass was made on foot within walking radius of Aroostook Farm and continued at other places whenever opportunities were presented the writer to extend the quest by the aid of automobile travel between hunting grounds, the most northern part visited in this way being Frenchville. The field assistant, Mr. Hubert Cooper, made many auxiliary trips using a bicycle between the points of search.

In reporting that during the summer no wild roses were found in the locations indicated (hedgerows, woodland fringes, swamp borders, and hillside growths) the writer, of course, does not wish to be interpreted as suggesting that there are no native roses in northern Aroostook (16). But the statement is hazarded that such native roses in the northern part of that county as there may chance to be would not seem to be abundant enough to jeopardize the potato seed industry by the number of pink and green aphids that could overwinter on them. Although in the situations indicated the writer did not find any roses that were apparently native to that locality there were nevertheless a great many uncultivated ones. They were occupying dooryards, preferably old dooryards, or running out from such places along a road a little distance as if escaped. The conspicuous absence of wild roses in the places that wild roses frequent in other parts of the State, made their presence about the old dooryards puzzling until the solution was offered by one familiar with rose culture that these "tame" wild rose clumps were the persisting hardy wild stocks upon which had been grafted the more tender cultivated varieties,

introduced north of their climatic range. There were this season about 2000 such wild rose stems in two old dooryards within easy aphid flight of Aroostook Farm. The difficulties of getting mosaic-free potatoes, in a locality that harbors to this extent the primary food plant of an insect known to spread potato mosaic, will be apparent.

The "tame" wild ones are not the only dooryard roses. Cinnamon roses abound in the same sort of neglected clumps in fence corners and in the vicinity of deserted houses and burned ruins. *Rosa rugosa* has been rather commonly planted; and here and there is a bed of Scotch roses, or a Rambler or two. On the front lawn at Aroostook Farm a clump of *Rosa rugosa* has stood,[10] adding its full quota to the army of aphids migrating to neighboring potato fields.

As a tour along the roads will convince any observing person, there are enough dooryard rose bushes in northern Aroostook to threaten any attempt to secure mosaic-free stock under present conditions. And the bulk of these rose bushes are growing in masses often a rod or more in diameter, or crowding the fence along nearly its entire length—a circumstance that indicates that they are a by-product of neglect and not a cherished adjunct to the premises. On more than one occasion the writer was told by the owner: *"Those?* oh, *they* are nothing but wild roses; our cultivated roses (indicating a few puny shoots) are over here!" And one could not help wondering if the "cultivated ones" would in time throw off the feeble symbol of their culture, and run to meet the rioting "wild roses" by the fence.

How Far Can an Aphid Fly?

The reader will see that the drift toward which this bulletin is tending is the pronouncement that the rose bush is a pernicious weed and the recommendation that all rose bushes (except those valued enough to be accorded annual anti-aphid treatment) should be ripped from ground that is dangerously near seed-potato fields. The question naturally arises: how far can an aphid fly?

[10]It has been arranged to have this clump removed before another season.

The writer cannot answer this question and, because of certain inherent difficulties[11] involved in the problem thus presented, would not care personally to undertake its solution. Fortunately we do not need to know how far a given individual *can* fly, so much as we need to know how far from a rose clump a potato field should be, to be out of danger of a real aphid infestation. This is a question that presents no especial experimental difficulties. We have but to "try it and see." If a field within half a mile of a rose clump suffers the patronage of the pink and green aphid, the rose clump can be grubbed out or de-aphidized; and the field in question thus removed farther from the source of contamination. Any rural neighborhood with a common interest in potatoes would be a favorable location for this experimental procedure. Proximity to a town where pleasure in rose bushes may not be tempered with profits from potatoes, would, of course, increase the personal difficulties in the situation. The writer saw many locations this summer where such procedure would seem practical enough: where potato farm after potato farm reached out from both sides of a straight road along which the abundant dooryard roses bore every indication of receiving less consideration than the well cared for potato plants that these same roses were menacing. For any one interested in producing certified potato seed, the writer would suggest the slogan: "A mile from the nearest rose bush."

Although the experimental evidence indicated is not at present available, certain data bearing on the case have accumulated during the observations of the summer:

In a series of fields at graduated distances from rose bushes infested with the spring forms of the pink and green aphid, the migrants and their summer progeny were found to be colonizing potato fields within a few rods of the bushes earlier than fields quarter of a mile distant; and fields half a mile away were so much later in becoming infested that the indication for weeks

[11]The small size of the aphids, the difficulty of recovering marked individuals of the spring migrants (they habitually seek the underside of a potato leaf) in the vast circumference of surrounding potato fields, the problematic influence of weather conditions in general and of the force and direction of the wind in particular, the fact that an aphid can progress "in relays" (the winged females of each successive generation extending the possibilities of the range), the character of the intervening vegetation: these are a few of the phases complicating the question as to how far the pink and green aphid can fly.

was that such fields would suffer very slightly in comparison with those nearer the roses. That such, in several instances, was not the case, was due to a combination of circumstances that might occur on certain years and not on others.

The summer of 1920 had been a "heavy" aphid season. Conditions, therefore, had been favorable for the development of a large number of ladybird beetles and other natural enemies to prey upon the aphids. The ladybird beetles, in consequence, were present among the spring colonies of the aphids on the rose bushes in 1921. Parasitic hymenoptera were also at work. The aphids were thus reduced to a considerable extent before it was time for them to migrate to the potato, and while migration was in progress the ladybirds and hymenopterous parasites after cleaning out the aphid remnants on the rose bushes, sought the new colonies on the potatoes nearest at hand and began reducing them there. This seemed to be the reason for the circumstance at Presque Isle in 1921 that in more than a few instances at nearly half mile distance from rose bushes had, in August, a heavier aphid infestation than fields within a few rods of the bushes.

Such, however, was not the general trend of the data nor would we expect this except on years when the insect enemies of the aphids are especially abundant in the spring of the year so as to be on duty at the rose clumps and, therefore, quick to find the same prey in the nearest potato fields.

In general it was found that the nearer the rose the heavier the infestation of the potato plants and this was so marked in certain localities that the site of the rose bushes could be traced by following a line of increasing infestation of the potato fields. The writer gained some experience in this phase of aphid detective work at various points in northern Maine, among which might be mentioned the vicinity of Frenchville. But because of the smaller size of the fields in northern New Brunswick, it is easier to relate definitely certain data made available by a visit early in August to the Chaleur Bay region—the "north shore" of New Brunswick.

Five fields on Shippigan Island were examined for aphids. None were found in the three further fields but two small fields near the ferry had each a light sprinkling of pink and green aphids. The logical inference would be that rose bushes were nearer the two small fields near the ferry. Such proved to be

the case for, though there were no rose clumps in sight, a careful search located the mown stems of living roses in the meadow which separated the two fields. That these were once cultivated roses was indicated by the circumstance that they were growing near a clump of lilacs—the site of some old dooryard with nothing left to mark it but the lilacs and the rose stubs.

The records of a peninsula near Shippigan are no less interesting. Here in the two fields which were visited first the aphids were fairly abundant. In the third field fewer were present, the number dwindled still lower in the fourth, and by the time the fifth field (perhaps a quarter of a mile from the first) was entered the infestation was found to be, by a conspicuous degree, slighter yet. The conclusion was obvious and in accordance with it a hunt for the rose bushes was undertaken with the result that they were found where they might have been expected—in the rear of the two first fields. They were growing along the walls of a cellar ruin, and it was interesting to notice that they were a different sort of rose from the "wild" rose of northern Maine dooryards, and different from those in other parts of even northern New Brunswick; for we found this "Shippigan rose" only in the old French districts, the dooryard roses of the localities settled by the Irish being quite another type.

A third case of special interest may be cited. Near "Black Rock," in the "north shore" district, there were two potato fields which, in 1920, had registered 100 per cent mosaic. These were separated from an overgrown mass of "wild" roses of the Shippigan type, by only a small field of hay and a small field of oats.

These and many other instances point to the conclusion that (a) potato fields near rose bushes are in greater danger of being attacked by the pink and green aphid than those farther removed from the source of infestation, and (b) even so short a distance as quarter of a mile may sometimes be great enough to make the difference between a heavy and a slight attack of aphids. Fields not nearer rose bushes than half a mile, as a rule, were subject to conspicuously less infestation than those at half that distance. There were many fields that, with apparently very little expense or trouble, could be given the benefit of a separation by a mile from a rose bush.

It seems likely that such fields would do much toward answering the question how far does a pink and green aphid fly?

REMEDIAL MEASURES.

Destruction of rose bushes. On the evidence of the case the logical verdict against the rose bushes would seem to be:—guilty of being a pernicious weed with reference to potato culture. A first aid to the seed-potato industry is the destruction of rose bushes that harbor the aphids that carry disease that weakens the potato that is a candidate for the southern markets. Of course this treatment would also improve conditions for table stock but the mosaic situation with reference to table potatoes is not so critical as it is with seed potatoes and expense of time and money justifiable in the former case might not always be practical in the latter. The time most favorable for the digging out of rose bushes would be the fall—October or November in northern Maine or New Brunswick, with a second grubbing in the spring if overlooked shoots are found to be starting up at that time. If this is not done in the fall any time before the first of May would serve the purpose. The bushes taken out should be burned in order to destroy the aphid eggs.

Treatment of rose bushes. Potato growers who have fields in cultivation near rose bushes not under their control, or who own rose bushes which they are unwilling to sacrifice, could still control the aphid situation by killing these insects on the rose. A thorough-going spray early in September and another in early June ought to reduce the numbers greatly; though, on account of the difficulties of securing 100 per cent mortality by spraying, fumigation would probably be a more certain method. Fumigation tents or large portable box cages could be run on a cooperative basis by the potato growers in a community; and rose bushes could be fumigated as citrus trees in the south, or nursery stocks, are treated.

Roguing, entomologically considered. It is becoming a common practice among growers of certified seed to cull out from their field the plants that show symptoms of mosaic. This process is termed "roguing." Because the mosaic symptoms are not always evident before the aphids migrate to the potatoes it is sometimes difficult to complete "roguing" until after the plants become colonized by these insects. If aphids are present in the field, it would seem desirable to have the plants which are "rogued out" removed at once from the vicinity or treated so as to render them harmless, for if such plants are thrown down

near the field, the aphids would leave the wilting vegetation for fresh plants and an enforced dispersal from diseased plants to well ones would occur, thus lessening the effectiveness of the roguing. If not removed at once it would seem desirable to dump the potato plants directly into old barrels where they could be crowded down and covered over with newspapers or a sack wet in kerosene.

No Rose Bushes—No Aphids?

It is the belief of the writer founded on nearly twenty years collecting acquaintance with the pink and green aphid that this insect in Maine has but one primary host on which it normally overwinters—the rose. The most scrupulous quest for spring forms of this species on vegetation other than the rose was continued this spring during the entire time that this aphid was active on the rose. It was not taken on anything except rose until after the migration season had begun. The New Brunswick fields were not visited until August so that data of this sort are not available there; but no fields were found in that province whose infestation by aphids could not easily be accounted for by neighboring rose bushes.

While it would be a rash thing to offer the pledge "no rose bushes—no aphids," this bulletin would be without a point if it were not backed by the faith that the destruction of the primary host (the rose) of the pink and green aphid would cause the collapse of that species at least to the extent that it could no longer function as it does now (by virtue of its numbers and fairly constant occurrence), as probably the most serious carrier of potato mosaic. The writer knows of no case in the north where any species of aphid attains the economic status of a serious pest in the absence of its normal primary host. In the south it is possible for many species to maintain themselves by virtue of a continuous viviparous reproduction and the overwintering eggs play a less important role than in a cold climate where they are a necessary link in the annual cycle.

No Aphids—No Mosaic?

In the judgment of the writer and certain plant pathologists[12] who have been watching the mosaic situation with reference to

[12]Drs. Donald Folsom and E. S. Schultz.

aphid infestation, there seems to be no guarantee for healthy potatoes in the vicinity of rose bushes. We know, from experimental evidence previously recorded (8) (11) (12) (14) (15) that aphids can and do carry potato mosaic and leafroll; we believe, from a series of apparently convincing circumstantial evidence, that the pink and green potato aphid is the insect most concerned with the field transference of potato mosaic in northern Maine and northern New Brunswick; and we think that such evidence is of sufficient importance to warrant the recommendation that rose bushes, in the vicinity of commercial potato fields, especially where certified stock is grown, should be removed or annually de-aphidized.

To summarize the apparently convincing evidence just indicated, the following circumstances might be mentioned: Mosaic has been observed to "spread" badly during a season of heavy aphid infestation; all fields under observation where the mosaic per cent is on the increase are near enough rose bushes to receive migrants from them; all fields under observation where the mosaic per cent has not been perceptibly increasing are either at a considerable distance from rose bushes or in location where conditions are otherwise unfavorable[13] to aphid life; the pink and green aphid, on account of its abundance, its manner of feeding, and its dispersal habits, is qualified to be a most effective cause of the spread of potato mosaic.

On the other hand while stressing the rose bush and the aphid, we are not to be interpreted as claiming that, in the elimination of the pink and green aphid, the problem of mosaic control has been solved. The possibility that certain other potato insects may be able to carry diseases should not be overlooked. While no other potato insect in the State can vie with the pink and green aphid in numbers, there are two other aphid species, frequenting fields to a slight extent, that might on an occasional season function as carriers of disease. Although the "apple leafhopper" or "potato leafhopper" *(Empoasca mali)* does not enter the northern fields of Maine enough to have any present economic bearing, chance leafhoppers of other species now and then visit the vines and certain froghoppers (Cercopids) are not uncommon. A shining black bug spotted with red *(Cos-*

[13]For further treatment of this item the reader is referred to the discussion of the New Brunswick situation, page 343.

mopepla carnifex) includes the potato in its dietary as do some other sucking bugs; but all these miscellaneous insects taken together did not, during the season of 1921, anywhere near approach the tarnished plantbug in numbers. If the tarnished plantbug *(Lygus pratensis)* is a carrier of potato disease, in economic importance it would possibly outrank, on account of its numbers, all the other Maine potato insects combined except the pink and green potato aphid.

But, the fact that there may be other insects guilty to a less extent of the same offense is obviously no argument against a campaign directed toward this aphid. That is, the possibility that a complete elimination of the spread of mosaic may not be attained is no reason for neglecting measures that promise to reduce such spread greatly.

THE SITUATION IN NEW BRUNSWICK.[14]

During the past few years considerable interest has centered in the "north shore" region because of the discovery that in certain potato fields, where mosaic control has never been practiced, the mosaic percentage is still so low as to suggest "immunity" from some cause or other. In remarkable contrast stand certain other fields in this same region where the mosaic counts have been known to run as high as 100 per cent. Such a situation challenged inquiry; and it was in the hope that an entomological survey of the fields of the northern part of the Province might throw some light on the peculiar conditions indicated, that the writer visited more than 80 of these fields during August, 1921, in company with Plant Pathologists[15] who were interested in the same cause. Fortunately for the observations of the writer, aphids *(Macrosiphum solanifolii)* were more than usually abundant in New Brunswick this season. Here, as has been shown to be true of the Aroostook fields, in each case the

[14]The writer is cordially assured by Mr. G. C. Cunningham, Plant Pathologist, Division of Botany, Dominion Experimental Farms, that the discussion of New Brunswick conditions in this bulletin is in no sense "trespassing."

[15]G. C. Cunningham, Division of Botany, Department of Agriculture, Dominion of Canada; Donald Folsom, Maine Agricultural Experiment Station; and E. S. Schultz, Bureau of Plant Industry, U. S. Department of Agriculture.

source of the infestation could be credited to neighboring door-yard rose bushes. Furthermore, in localities where both the potato field and the rose bushes were sheltered from the prevailing winds, both the aphid and the mosaic conditions seemed comparable with those of similar situations in northern Aroostook.

In general the aphids were conspicuously more abundant in sheltered fields near sheltered rose bushes than in localities where both the potato plants and neighboring rose bushes were exposed to heavy winds. That the winds and the weather play an important role in the plant life bordering Chaleur Bay, one need only glance at the leaning willows to know. The potato leaves in unsheltered fields were in tatters, and those of neighboring weeds shredded and drying. It seemed a logical inference to draw that, where rose bushes and potato fields both stood in the sweep of such blasts, conditions for delicate bodied aphids would not be favorable. The best guess, then, that we could make was that the reason the mosaic percentage was so low in certain localities along the north shore was that the winds, to a great extent, have de-aphidized the rose bushes.

If our assumption is correct, the situation in New Brunswick gives an added encouragement to an attempt to duplicate conditions there to the extent of making life difficult for the pink and green aphid. No better or easier way of doing this can be suggested than the removal of rose bushes and thus destroying their primary foodplant.

While in northern New Brunswick in exposed situations, the rose bushes (for the reason previously indicated) do not seem to function to so great an extent as a danger to potato industry as in other more sheltered situations, still even there conditions might be rendered more favorable to potato culture by lessening the number of rose bushes wherever practicable.

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